

**STATUS OF MINERAL RESOURCE INFORMATION FOR THE
SOUTHERN UTE INDIAN RESERVATION, COLORADO**

By

W. P. Pratt
U. S. Geological Survey

W. C. Henkes
U. S. Bureau of Mines

Administrative Report BIA-19
1976

CONTENTS

SUMMARY AND CONCLUSIONS	1
INTRODUCTION	1
Geographic Setting	1
Present Study	2
Labor Force	2
GEOLOGY	2
Previous Geologic Investigations	2
General	3
Rock Units	3
General	3
Jurassic System	3
Wanakah Formation	4
Morrison Formation	4
Cretaceous System	5
Burro Canyon Formation	5
Dakota Sandstone	5
Mancos Shale	5
Mesaverde Group (Formation)	5
Point Lookout Sandstone	6
Menefee Formation	6
Cliff House Sandstone	6
Lewis Shale	6
Pictured Cliffs Sandstone	7
Fruitland Formation	7
Kirtland Shale	7
Cretaceous and Tertiary Systems	8
Animas Formation	8
Tertiary System	8
Ojo Alamo Sandstone	8
Nacimiento Formation	9
San Jose Formation	9
Geologic Structure	9
MINERAL RESOURCES	10
General	10
Petroleum and Natural Gas	10

Ignacio-Blanco Gasfield	11
Mesaverde Reservoir	12
Fruitland-Pictured Cliffs Reservoir	12
Dakota Reservoir	12
Alkali Gulch Gasfield	13
Red Mesa Oilfield	13
Coal	13
General	13
Dakota Formation	14
Menefee Formation	15
Fruitland Formation	16
Uranium	16
Sand and Gravel	16
MINERAL LEASING	17
MINERAL MARKETS AND TRANSPORTATION	18
MAP COVERAGE	18
RECOMMENDATIONS	19
Oil and Gas	19
Coal	19
REFERENCES	20

SUMMARY AND CONCLUSIONS

Minerals being produced on the Southern Ute Indian Reservation are natural gas, petroleum, coal, and sand and gravel. Royalties from natural gas production contributed 99.7 percent of the mineral royalties accruing to the tribe in the period 1970-1974.

A price for natural gas approaching the free market value of the commodity would probably result in much fill-in drilling in the Ignacio Blanco gasfield. Most of the field has been drilled on 320-acre (130-ha) well spacing; well density could be increased to 160-acre (65-ha) spacing probably with increased ultimate gas recovery. With the incentive of higher prices, the undrilled areas in T. 32 N., Rs. 8-9 W., in the deeper part of the San Juan Basin, may be drilled.

The most favorable possibilities for coal development appear to be the Menefee and Fruitland Formations, or their equivalents, in the western and eastern parts of the reservation. Action of Peabody Coal Co. on its lease blocks may influence coal activity in the area in the near future. It is doubtful that additional office studies could contribute significantly to the data assembled by Shomaker and Holt (1973). Drilling of exploratory holes in the areas of shallow coal deposits would be costly and may not be justified until Peabody decides what action to take on its lease.

Uranium might occur in the buried portions of the Morrison and Cutler Formations.

INTRODUCTION

Geographic Setting

The Southern Ute Indian Reservation is in southwestern Colorado adjacent to the New Mexico boundary ([Figure 1](#)). The reservation encompasses an area about 15 miles (24 km)¹ wide and 72 miles (116 km) long; total area is approximately 818,000 acres (331,000 ha). Of the Indian land, 301,867 acres (122,256 ha) are tribally owned and 4,966 acres (2,011 ha) are allotted lands; 277 acres (112 ha) are federally owned (U.S. Department of Commerce, 1974). The tribal land is fairly concentrated in two blocks: one in Ts. 32-33 N., Rs. 1-6 W., and the others in Ts. 32 N., Rs. 8-13 W. and T. 33 N., R. 11 W. Most of the allotted land is along or near Los Pinos River ([Figure 1](#)).

Topography of the reservation is generally rugged. West of Animas River, the eastern flank of Mesa Verde is cut by numerous small canyons.

¹Conversion of English units of measure to metric units has been made using the following factors. No attempt has been made to convert barrels of oil to metric tons (tonnes) because such conversion varies according to the specific gravity of the oil.

English Unit	X	Factor	=	Metric Unit
Acre		0.405		Hectares (ha)
Btu/ft ³		8.8999		Kilogram-calories /cubic metre (kg-cal/m ³)
Btu/lb		0.55556		Kilogram-calories /kilogram (kg-cal/kg)
Ft ³		0.028317		Cubic metres (m ³)
Ft		0.305		Metres (m)
Mile		1.61		Kilometres (km)
Short ton		0.9072		Metric tonne (t)

Eastward the hills become more rounded and more timber covered. Altitudes range from about 6,000 feet (1,830 m) along La Plata River near the southwest corner and along the San Juan River near Arboles to 8,551 feet (2,608 m) at Piedra Peak (sec. 24, T. 33 N., R. 6 W.). Principal streams in the reservation are the San Juan, Piedra, Animas, Florida, and La Plata Rivers. The Navajo Reservoir, formed by Navajo Dam in New Mexico, forms a significant body of water on the San Juan River and the lower Piedra River in the eastern part of the reservation; water surface is at an altitude of about 6,100 feet (1,860 m).

Numerous paved roads cross the reservation; gravel roads provide access to the farmland and most of the area ([Figure 1](#)). Unpaved roads to oil and gas wells allow access to most of the western part of the reservation. Much of the rest of the area can be reached by trails.

Ignacio, with a population of 613 in 1970, is the largest town on the reservation, and site of the Southern Ute Indian Agency. Several smaller towns are shown on [Figure 1](#). The nearest large town is Durango, Colo., with a population of 10,333, about 5 miles (8 km) north of the reservation. To the south, Farmington, N. Mex., with a population of 21,979 (1970), is about 29 miles (47 km) from the reservation boundary.

Present Study

This report was prepared for the U.S. Bureau of Indian Affairs by the U.S. Geological Survey and the U.S. Bureau of Mines under an agreement to compile and summarize available information on the geology, mineral resources, and potential for

economic development of certain Indian lands. Source material was published and unpublished reports, as well as written communication. There was no field work.

Labor Force

Data supplied by the Southern Ute Agency (U.S. Bureau of Indian Affairs, written commun., Raymond DeKay, Nov. 20, 1975) list the Indian population within or adjacent to the reservation of 1,022. Of these, 514 are males and 508 are females. The labor force in 1975 is listed in [Table 1](#).

Over two-thirds of the labor force are in the prime age groups for workers; 52.4 percent are in the 16- to 24-year bracket and 70.1 percent are in the 16- to 34-year range.

GEOLOGY

Previous Geologic Investigations

The geology of the Reservation is shown on three detailed maps prepared in the late 1940s and early 1950s; from west to east these maps cover the Red Mesa area (Barnes and others, 1954), the Ignacio area (Barnes, 1953), and southern Archuleta County (Wood and others, 1948). They were the main source of information for the parts of the Reservation covered by the Cortez and Durango 1°-2° quadrangles (Haynes and others, 1972; Steven and others, 1974). Fassett and Hinds (1971) discuss in detail the geology of the Fruitland Formation and Kirtland Shale in the area; Shomaker and Holt (1973) describe in detail the coal resources of the reservation.

TABLE 1
Resident Indian Population of Working Age, 1975

Age Group, Years	Male	Female	Total
16-19	88	87	175
20-24	90	101	191
25-34	67	57	124
35-44	35	42	77
45-64	46	43	89
65 years and over	<u>22</u>	<u>21</u>	<u>43</u>
	348	351	699

General

The Southern Ute Indian Reservation is on the northern margin of the San Juan Basin, a large circular structural depression whose center is some 50 miles southeast of Durango. The sedimentary layers that fill the San Juan Basin dip gently toward its center, and their outcrop pattern around the basin is a series of concentric bands, with the younger rocks toward the center and the older ones toward the margin (Figure 2). Nearly all the rocks exposed at the surface on the Reservation are sedimentary rocks of Late Cretaceous or Early Tertiary age.

Rock Units

General

The Wanakah Formation is the oldest formation exposed on the reservation. Beneath it in the subsurface are about 5,700 ft. of older sedimentary rocks that have been penetrated by wells drilled for oil and gas, and below these are older sedimentary

rocks and "basement" rocks that are known either from the deepest holes or from outcrops in adjacent areas. The subsurface rock units are listed in Table 2.

The geologic formations exposed on the reservation (Table 3) are briefly described below, from oldest to youngest. On the geologic map (Figure 2), some of these formations are grouped together for better legibility.

Jurassic System

Jurassic formations are exposed only in the valley of the San Juan River in the "outlier" at the northeast corner of the reservation. They underlie the entire reservation in the subsurface.

TABLE 2
Subsurface Rock Units Below the Wanakah Formation in the Southern Ute Indian Reservation
(Descriptions and thicknesses from Steven and others, 1974)

Jurassic System

Entrada Sandstone. Light-gray crossbedded sandstone. Maximum thickness about 250 ft. (75 m).

Triassic System

Upper Triassic Series

Dolores Formation. Mostly nonmarine red shale, siltstone, sandstone, and limestone-pebble conglomerate. Maximum thickness about 600 ft. (180 m).

Permian System

Lower Permian Series

Cutler Formation. Mostly nonmarine red shale, siltstone, mudstone, and arkosic grit and conglomerate. Maximum thickness about 2,000 ft. (610 m).

Permian and Pennsylvanian Systems

Rico Formation. Nonmarine red beds of shale, siltstone, arkosic sandstone, and grit; represents transition between Cutler and Hermosa Formations. Maximum thickness about 350 ft. (105 m).

Pennsylvanian System

Hermosa Formation. Largely dark-gray marine shale, limestone, and sandstone. Includes the salt-bearing Paradox Member, from which gas is produced in the Alkali Gulch field (see under Mineral Resources). Maximum thickness about 2,500 ft. (760 m).

Older Formations (from youngest to oldest): Molas Formation (Pennsylvanian, Leadville Limestone (Lower Mississippian), Ouray Limestone and Elbert Formation (Upper Devonian), Ignacio Quartzite (Upper Cambrian), metamorphic and igneous rocks (Precambrian).

Wanakah Formation

The Wanakah Formation consists of three members. The Pony Express Limestone Member at the base is a dark-gray thin-bedded bituminous limestone that locally contains gypsum and sandstone. It is about 25 ft (8 m) thick where exposed but may be thicker in the subsurface. The middle member is limy shale, siltstone, and sandstone. The Junction Creek Sandstone Member at the top is

light-gray crossbedded sandstone. Maximum thickness of the Wanakah is about 300 ft (90 m). Its age is Late Jurassic and it is overlain conformably by the Morrison Formation.

Morrison Formation

The lower or Salt Wash Member of the Morrison is mostly sandstone with interbedded claystone and mudstone; the overlying Brushy Basin Mem-

ber is mostly varicolored claystone and mudstone. Maximum thickness of the Morrison is about 800 ft (240 m). It is Late Jurassic in age and is overlain disconformably by the Burro Canyon Formation.

Cretaceous System

Burro Canyon Formation

Like the Jurassic rocks, the Burro Canyon is exposed only at the northeast corner of the reservation. It consists of about 100 ft (30 m) of lenticular chert-pebble conglomerate interlayered with green and gray claystone. It is of Early Cretaceous age.

Dakota Sandstone

The Dakota Sandstone is exposed only in the valley of the San Juan River in the northeast corner of the reservation, but it underlies the entire reservation in the subsurface. North of the reservation it consists of a lower member of conglomeratic sandstone, a middle member of carbonaceous silty shale, and an upper member of medium- to fine-grained sandstone. Its thickness on the reservation is not known, but nearby to the north it is 177-270 ft (54-82 m) thick. The Dakota is of Late Cretaceous age and lies either disconformably over the Burro Canyon Formation or unconformably over the Morrison Formation.

Mancos Shale

The Mancos Shale underlies the entire Reservation and is exposed within a few miles north of the reservation all along its northern boundary, but

the only Mancos outcrops within the reservation are in the northeast corner. It is mostly a dark gray marine shale and its maximum subsurface thickness in the reservation is about 2,400 ft (about 730 m). The lower part, about 500 ft (150 m) thick, contains thin limy shale and limestone in the lower 150 feet. The upper part, about 1,900 ft (580 m) thick, has sandy limestone and clayey sandstone at its base and contains some limestone or limy beds in its lower 600 feet; it grades upward into fine-grained shaly sandstone. The Mancos is Late Cretaceous in age; it overlies the Dakota Sandstone conformably, and intertongues with the overlying Point Lookout Sandstone.

Mesaverde Group (Formation)

Overlying the Mancos Shale is a series of interbedded sandstones and shales, which east of the Los Pinos River are considered a single formation, the Mesaverde Formation, but to the west are raised to group rank and subdivided into three formations--from the base up, the Point Lookout Sandstone, the Menefee Formation, and the Cliff House Sandstone. The Mesaverde Formation forms several small mesas in the northeastern part of the Reservation. The outcrop continues to the west in an arc north of the Reservation, and reenters it on the west side, where the Cliff House Sandstone lies at the surface of nearly all the Reservation west of the La Plata River. The entire group is of Late Cretaceous age.

The Mesaverde Formation consists of interbedded thin sandstone ledges and dark-gray clay shale, with minor carbonaceous shale and coal. Its maximum thickness is about 350 ft (about 105 m).

Point Lookout Sandstone.--The lower part consists of yellowish gray fine-grained sandstone and siltstone interbedded with gray sandy shale; the upper part is composed of massive fine- to medium-grained tan to white sandstone that forms conspicuous cliffs above the Mancos Shale north and west of the Reservation. Maximum thickness is about 400 ft (about 120 m). The contact with the overlying Menefee Formation is conformable and sharp in most places and is at the base of the lowest bed of coal or carbonaceous shale above the massive sandstones.

Menefee Formation.--This consists of a series of interbedded lenses of sandstone, siltstone, shale, and (most notably from an economic viewpoint) coal. Irregular bedding and rapid lateral changes of lithology are characteristic of the formation, and in one place, about 15 mi north of Ignacio, the middle part of the formation is more than 200 feet of massive, cliff forming sandstone. The sandstones and siltstones are various shades of light gray and yellowish gray and range in grain size from coarse sand to very fine silt; the shales are mostly shades of dark gray or brown. The coal beds are lenticular and in many places grade both horizontally and vertically into carbonaceous clay shale and carbonaceous shaly sandstone. Thin coal beds occur throughout the formation, but most coal beds more than 1.2 ft (0.4 m) thick are in the lowermost 50-60 ft (15-18 m) of the formation, and a few are immediately below the top. The Menefee is at most about 350 ft (105 m) thick; its contact with the overlying Cliff House Sandstone is disconformable, but locally the two formations intertongue.

Cliff House Sandstone.--This consists of sandstone, siltstone, and shale in varying proportions, with sandstone becoming more predominant toward the southwest. On Weber Mountain, a few miles northwest of the Reservation, the Cliff House consists of an upper sandstone unit 65 ft thick, a middle shaly unit 210 ft thick, and a lower sandy unit 70 ft thick. But the shaly unit wedges out within a few miles southward, so that the Cliff House at and beneath the surface in the western part of the Reservation may be presumed to be predominantly sandstone. The total thickness is about 350 ft (105 m), but some of this has been eroded where the formation is at the surface. The contact with the overlying Lewis Shale is sharp and conformable.

Lewis Shale

The Lewis Shale crops out on the west side of the Reservation in a northeast-trending band marked by Long Hollow, and on the east side in a wide sinuous zone that trends northwest from Archuleta Mesa. The formation is predominantly a dark-gray soft shale that erodes easily to form valleys or lowlands. Thin lenticular beds and concretions of rusty-weathering Limestone may occur in the lower or upper part of the formation. Thin beds of fine-grained sandstone are also present, and increased sandiness in the upper part of the formation indicates an intertonguing transition into the overlying Pictured Cliffs Sandstone. The Lewis Shale is Late Cretaceous in age; its thickness ranges from about 1,440 ft (440 m) to 1,825 ft (555 m) on the west side of the Reserva-

tion, and increases eastward to about 2,400 ft (730 m) on the east side.

Pictured Cliffs Sandstone.--The Pictured Cliffs Sandstone forms a conspicuous hogback from Cinder Buttes to Bridge Timber Mountain on the west side of the Reservation, and on the east side forms the lower part of the steep northeast-facing slopes that extend from Archuleta Mesa to the Piedra River. In its western exposures the formation is from about 215 ft (65 m) to 285 ft (85 m) thick; the lower two-fifths consists of interbedded sandstone and shale marking the transition from the Lewis Shale below, and the upper part consists of ledge-forming sandstone. The formation thins eastward to 90 ft (27 m) on Klutter Mountain just east of the Reservation, but the general lithology remains the same. The age of the Pictured Cliffs Sandstone is Late Cretaceous. The contact with the overlying Fruitland Formation is conformable, with local intertonguing.

Fruitland Formation.--The Fruitland Formation is a sequence of interbedded and locally carbonaceous sandstones, siltstones, and shales, coal, and locally in the lower part of the formation, thin limestone beds. On the west side of the Reservation the formation forms low ridges and small valleys on the gentle backslope of the Pictured Cliffs hogback; on the east side it crops out continuously from Archuleta Mesa to the Piedra River. The lithology of the formation is characterized by lateral discontinuity, most individual beds pinching out within a few hundreds of feet; the coal beds, however, are more continuous and may be traced for several miles. The formation is also character-

ized by vertical changes in lithology. Although coal beds occur throughout the formation, the thickest and most persistent beds are in its lower part. The limestone beds are found only in the lowermost part of the formation, sandstone is usually more abundant in the lower part than in the upper part, and siltstone and shale predominate in the upper part. However, the tan quartzose sandstone of the Pictured Cliffs type in the lower part of the Fruitland grades upward through the formation to pale-olive chloritic thin-bedded sandstone and shale typical of the overlying Kirtland Shale. The formation ranges from about 300 ft (90 m) to 500 ft (150 m) thick on the west side of the Reservation, but thins eastward to about 300 ft (90 m) in its outcrop area on the east side. The age of the Fruitland Formation is Late Cretaceous. The contact with the Kirtland is gradational; Fassett and Hinds (1971, p. 19) accept the usage of most geologists working in the San Juan Basin in placing the top of the Fruitland at the top of the highest bed of coal or carbonaceous shale.

Kirtland Shale.--The Kirtland Shale consists predominantly of shale, with interbeds and lenses of sandstone and siltstone. On the west side of the reservation it forms two valleys and an intervening ridge southeast of and parallel to the outcrop belt of the Fruitland Formation. It thins eastward and wedges out in the area between Cat Creek and Archuleta Mesa. Fassett and Hinds (1971, p. 23-24) recognize a twofold division of the formation: the lower shale member, and an upper unit consisting of the Farmington Sandstone Member and the upper shale member. The lower shale member is composed of gray and brown shale and silty shale

and rare sandstone interbeds. The upper unit consists of interbedded arkosic sandstone lenses and shale; the shale interbeds in the lower part of the upper unit are like the lower shale member, but the shale interbeds at the top are much more colorful--purple, green, white, and gray. The lower member ranges from about 250 to 300 ft (75 to 105 m) thick along the outcrop on the west side, but thins eastward and wedges out in the subsurface between Arboles and Juanita. The upper unit also thins eastwardly, from 800-1200 ft (240-370 m) on the west side to its pinchout between Juanita and Archuleta Mesa. The contact between the Kirtland and the Animas Formation, which overlies it in most of the Reservation, is transitional and arbitrary. The age of the Kirtland is Late Cretaceous.

Cretaceous and Tertiary Systems

Animas Formation

Immediately overlying the Kirtland Shale over most of the Reservation is the Animas Formation, which crops out in a band of variable width forming an east-west arc across the Reservation. The Animas is characterized by conglomerate beds, containing boulders and pebbles of andesite in a tuffaceous matrix, interbedded with variegated shale and sandstone. In the western part of the Reservation the Animas has been divided into two members (Barnes and others, 1954): the McDermott Member below consists of dominantly purple beds of breccia, conglomerate, tuffaceous sandstone, and shale; the unnamed upper member is composed of greenish-gray, olive, and tan beds of less coarsely conglomeratic andesitic sandstone

with scattered thin shale interbeds and thin coal beds; the coarseness of the clastic material decreases generally from bottom to top. To the east across the Reservation, the McDermott Member pinches out and the Animas is not subdivided. On the west side of the Reservation the McDermott Member has a maximum reported thickness of 290 ft (88 m), which thins to the south and east; and the upper member has a maximum thickness of 1,110 ft (338 m). Eastward the undivided Animas Formation thickens to a maximum of 2,670 ft (815 m) near the La Plata-Archuleta County line (north of the Reservation), and then thins to 1,840 ft (560 m) on Cat Creek (Reeside, 1924, pl. 2). The McDermott is Late Cretaceous in age. The upper member, and the undivided Animas Formation, are considered Late Cretaceous and Paleocene, but where the formation overlies the Ojo Alamo Sandstone in the southeast part of the Reservation its age is only Paleocene.

Tertiary System

Ojo Alamo Sandstone

The Ojo Alamo Sandstone crops out only in the southeast corner of the Reservation, overlying the Kirtland Shale in a thin band south and west of Montezuma Mesa; in the subsurface it continues west and south, but pinches out northward along a line passing south of Ignacio and Bondad. The Ojo Alamo consists of overlapping sheetlike massive beds of brown arkosic sandstone, interbedded with minor shale. Toward the west (in the subsurface) the sandstone becomes conglomeratic. The maximum thickness of the Ojo Alamo on the Reserva-

tion is not known exactly, but judging from the outcrop pattern it probably does not exceed a few tens of feet. The age of the Ojo Alamo is Paleocene.

Nacimiento Formation

The Nacimiento Formation overlies the upper member of the Animas Formation in the vicinity of McDermott Arroyo and the Animas River. It is a sequence of variegated tuffaceous shale and brown lenticular sandstone, transitional in color and lithology from the underlying Animas, and in general finer grained. Its maximum thickness is about 350 ft (105 m), and it is overlain conformably by the San Jose Formation. Its age is Paleocene.

San Jose Formation

The San Jose Formation, the youngest formation filling the interior of the San Juan Basin, is a sequence of interbedded sandstone, shale, and tuff. The sandstones are grayish yellow, conglomeratic to fine-grained, and medium to massive-bedded, and in most places tend to form cliffs. The shale is chiefly red and sandy, and has been eroded to form steep slopes between the sandstone cliffs. The tuffs are light gray to white and form thin ledges. The base of the formation in the southern part of the area is a massive cliff-forming conglomeratic sandstone that rests unconformably on the Nacimiento, but toward the north this sandstone becomes thinner and less resistant, forming a slope. In the area of Bridge Timber Mountain the San Jose extends beyond the Nacimiento and lies

unconformably on strata of the Animas Formation (both members) and the Kirtland Shale where they are tilted up along the northwest rim of the San Juan basin. The maximum known thickness of the San Jose Formation is about 2,500 ft (760 m). Its age is Eocene.

Geologic Structure

The structural setting of the Southern Ute Indian Reservation ([Figure 2](#)) is dominated by the San Juan Basin, whose northern flank occupies nearly three-fourths of the reservation's area. The geographic center of the basin is about 25 miles south of the reservation. However, the basin is asymmetrical, with its northwest slope steep and its southwest slope gentle; the deepest part is about 7 miles south of Arboles (Fassett and Hinds, 1971, fig. 15). Beyond the rim of the basin the major structural elements are the Four Corners Platform on the west and the Chama Basin on the east; the rim itself is marked by the Hogback monocline, which crosses the west side of the reservation, arcs around it to the north, and re-crosses it at the east end. Superimposed on these major structures are several smaller ones: the Barker anticline and Red Horse syncline in the southwest corner of the reservation, the Ignacio anticline and H-D Hills syncline in the central part, and several northwest-trending anticlines, synclines, and faults at the east end. The principal structures of economic significance are the Barker anticline which produces gas from the Dakota and Hermosa formations, and the Ignacio anticline, which produces gas mainly from the Mesaverde and subordinately from several

other formations from the Fruitland down to the Morrison (see under Mineral Resources).

Two areas of uncertainty remain in the subsurface structure of the reservation. First, the structure contours west of long. 108° in [Figure 2](#) (structure map) must be considered diagrammatic, because along the line of intersection between the two maps that provided this information, the structure contours on the base of the Dakota Sandstone fail to agree by as much as 2,000 feet (although they do agree in general trend and slope); for the purpose of compiling [Figure 2](#), preference has been given to the elevations shown on the more recent source map, that of the area east of 108° (the Durango quadrangle of Steven and others, 1974). Thus the structure contours west of 108° on [Figure 2](#) are based on the trends shown in the map of the Cortez quadrangle (Haynes and others, 1972), but the elevations were arbitrarily extended from the Durango quadrangle. Second, detailed knowledge of subsurface structure in the southeastern part of the reservation is lacking, as indicated by the absence of structure contour on [Figure 2](#), and this gap cannot be filled on the basis of information now available. The anticlines and synclines in R. 3 W. near the southeast corner of the reservation were mapped by Wood and others (1948), but the depth to which they extend is not known.

MINERAL RESOURCES

General

Mineral resources of value or potential value in the Southern Ute Indian Reservation include

petroleum and natural gas, coal, and sand and gravel. Of these, natural gas is the most important ([Figure 3](#)).

Petroleum and Natural Gas

Information compiled by the Conservation Division of the U.S. Geological Survey ([Table 4](#)) (Jack Darrough, written commun., Dec. 12, 1975) shows that the tribe received \$1.7 million in royalties from oil and gas in the 5-year period from 1970 through 1974, and allottees received \$78,321. Of the tribal receipts, 99.7 percent were from natural gas. The effect on tribal income of the commodity price increases starting in 1973 is clearly evident in [Table 4](#). Petroleum output, though small, increased 56.2 percent in quantity, but increased 274.1 percent in value. Natural gas declined 16.6 percent in quantity but royalty value was up 34.1 percent. Total tribal royalties increased 34.6 percent.

Within the boundaries of the reservation are two gasfields and one oil and gasfield ([Figure 3](#)). The most important production is from the northern part of the large Ignacio-Blanco gasfield that underlies most of the northern San Juan Basin of New Mexico and Colorado. Because of the interspersed non-Indian lands within the reservation, the discussions of the fields and their production will not attempt to distinguish among tribal, allotted, and fee lands.

In August 1974, Cities Service Oil Co. discovered a small amount of natural gas at its No. 1 Federal-B well, sec. 2, T. 34 N., R. 13 W., about 1 mile (1.6 km) north of the reservation. The well had an initial potential of 1 million ft (28,000 m)

of gas and 12 barrels of condensate per day. The following year, the company drilled another well about 3 miles (5 km) south but it was dry. The significance of the discovery and development of a market await the discovery of sufficient gas to justify the construction of a costly pipeline to the area.

Ignacio-Blanco Gasfield

The Ignacio-Blanco gasfield is a large gasfield underlying most of the northern part of the San Juan structural basin. The gasfield is mostly in New Mexico but extends into southern Colorado.

In this report only that portion in Colorado and on the Southern Ute Indian Reservation will be discussed ([Figure 4](#)). The field consists of three principal producing reservoirs (all of Cretaceous age): (1) The Mesaverde Group units -- The Point Lookout and Cliff House Sandstones; (2) the Dakota Formation; and (3) the Pictured Cliffs and Fruitland Formations (production combined). Relatively minor production is obtained from the Lewis Shale (Cretaceous), and one well in the Colorado portion has combined production from the Dakota and Mesaverde ([Table 5](#)). The three principal reservoirs are discussed separately.

TABLE 5
Production of Crude Oil and Natural Gas, by Reservoir, Ignacio-Blanco Gasfield, Archuleta and La Plata Counties, Colorado, 1974
(Adapted from Colorado Oil and Gas Conservation Comm., 1975)

Reservoir	No of Wells	Production			
		1974		Cumulative (1/1/75)	
		Oil bbl.	Gas (sold) Mcf	Oil bbl.	Gas Mcf
Mesaverde	379	66	15,810,076	4,904	338,376,576
Fruitland-Pictured Cliffs	8	48	85,159	94	32,853,075
Dakota	83	0	7,365,308	0	157,365,881
Lewis Shale	2	0	83,311	0	2,270,220
Dakota-Mesaverde	<u>1</u>	<u>0</u>	<u>44,317</u>	<u>0</u>	<u>534,494</u>
	473	114	23,388,171	4,998	531,400,246

Mesaverde Reservoir

Mesaverde gas in commercial quantities was first found in 1927 in a well drilled in sec. 29, T. 30 N., R. 9 W., San Juan County, N. Mex., near the town of Blanco. After completion of El Paso Natural Gas Co.'s 24-in (61-cm) gas pipeline to southern California, development drilling conducted in the 1950's extended production into Colorado.

Reservoir characteristics of the Mesaverde vary by location (Rocky Mountain Association of Geologists, 1962, p. 62). Porosity averages about 9 percent and permeability ranges from 0.02 to 0.5 millidarcies; high permeability zones occur as a result of natural fractures. Maximum reservoir thickness is 70 feet (21 m) and producing depths range from 5,000 to 6,000 feet (1,500 to 1,800 m).

The produced gas has a heating value ranging from 970 to 1,040 Btu per cubic foot (8,633 to 9,256 kilogram calories per cubic meter, kg-cal/m³). It contains (in mole percent) 92.0 to 97.0 percent methane, 0.5 to 3.5 percent ethane, and 2.0 to 3.0 percent carbon dioxide. Hydrogen sulfide content is nil.

Records of the Colorado Oil and Gas Conservation Commission (1975, p. 25, 39-48) ([Table 5](#)) show that total Mesaverde production in 1974 was 15.8 billion ft³ (447.4 million m³) of marketed gas and 66 barrels of oil (condensate). Cumulative production to the end of 1974 was 338.4 billion ft³ (9.6 billion m³) of gas and 4,904 barrels of oil.

Fruitland-Pictured Cliffs Reservoir

Although the first Pictured Cliffs discovery in the basin was in 1927 in San Juan County, N. Mex., the first discovery in the Colorado portion was not until 1951. This well, the Stanolind Oil and Gas Co., Ute Indian B-2, SW¹/₄NE¹/₄NW¹/₄ sec. 21, T. 33 N., R. 7 W., was completed for an initial potential of 3.12 million ft³ per day (88,300 m³) (Petroleum Information, 1951, p. 91).

Average thickness of the Fruitland-Picture Cliffs gas zone is 245 feet (75 m) with a maximum of about 460 feet (140 m). Porosity averages 4.4 percent and permeability ranges from zero to 15,000 millidarcies. A typical gas analysis (mole percent) shows 97.18 percent methane, 1.69 percent carbon dioxide, and small amounts of ethane and nitrogen. Average heating value of the gas is 990 Btu/ft³ (8,811 kg-cal/m³) (Rocky Mountain Association of Geologists, 1962, p. 58).

The Colorado Oil and Gas Conservation Commission, (1975, p. 41-42) reported that in 1974, 8 wells in the Colorado portion of the field produced 48 barrels of crude oil (condensate) and 85.2 million ft³ (2.4 million m³) of marketable gas. Cumulative production to the end of 1974 was 94 barrels of condensate and 32.9 billion ft³ (931.6 million m³) of natural gas ([Table 5](#)).

Dakota Reservoir

As was the case with other productive reservoirs in the Ignacio-Blanco field, Dakota production was discovered in the New Mexico portion--near Bloomfield, N. Mex. The discovery well in the Colorado portion was the Stanolind Oil and

Gas Co. (now Amoco Production), Ute Indian No. 1, SE $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 18, T. 33 N., R. 7 W., which was completed in November 1950 for an initial potential of 3.78 million ft³ (107,000 m³) per day (Petroleum Information, 1950, p. 21).

Reservoir porosity averages 7.5 percent and permeability ranges from 0.02 to 0.7 millidarcies; some high permeability zones exist because of natural fractured zones. Producing depths range from 7,800 to 8,600 feet (2,400 to 2,600 m). The gas, with a heating value of 950 to 990 Btu/ft³ (8,455 to 8,811 kg-cal/m³), contains (mole percent) 90.8 to 95.8 percent methane, 0.10 to 5.07 percent ethane, and 2.0 to 4.6 percent carbon dioxide, plus small amounts of propane, butane, and nitrogen. Hydrogen sulfide content is nil (Rocky Mountain Association of Geologists, 1962, p. 66).

State records show that in 1974 (Table 5) the Dakota reservoir had 83 wells that produced 7.4 billion ft³ (208.6 million m³) of marketable natural gas. Cumulative production was 157.4 billion ft³ (4.5 billion m³) of gas (Colorado Oil and Gas Conservation Commission, 1975, p. 39-41).

Alkali Gulch Gasfield

The Alkali Gulch gasfield (Figure 4) was discovered in May 1957 with successful completion of the General Petroleum Corp. (now Mobil Oil Corp.), Cater No. F-11-32, NW $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 32, T. 34 N., R. 12 W. The well was completed flowing gas at the rate of 15.8 million ft³ (447,000 m³) per day from the Lower Hermosa Formation (Pennsylvanian) at a depth of about 9,450 feet (2,880 m). Subsequently, seven producing wells were drilled in the field.

The reservoir has a pay thickness of 8 feet (2.4 m), a porosity of about 8 percent, and a permeability of 10 millidarcies. The gas has a heating value of 967 Btu/ft³ (8,606 kg-cal/m³).

In 1974, two wells in the field produced 304.4 million ft³ (8.6 million m³) of natural gas. Cumulative production to the end of 1974 was 20.9 billion ft³ (592 million m³).

Red Mesa Oilfield

The early history of the Red Mesa field (Figure 4) is obscured by poor records and lack of data. The discovery well was completed in 1924; however, no records have been found giving the name of the well, its precise location, or the initial production. It is known that production was from the Dakota Formation and the well was in sec. 23, T. 33 N., R. 12 W.

In 1974, 24 wells produced oil or gas from the Dakota, Gallup, Mancos, and Mesaverde horizons. Crude oil was 37° API gravity. The Dakota produced both oil and gas, the Gallup and Mancos produced oil only, and the Mesaverde produced gas only. Oil production in that year was 20,951 barrels, mostly from the Gallup, and 24.8 million ft³ (702,000 m³) of natural gas. Cumulative production to the end of 1974 was 504,279 barrels of oil and 563.9 million ft³ (16.0 million m³) of gas.

Coal

General

Coal resources of the reservation are in the Dakota, Menefee, and Fruitland Formations of

Late Cretaceous age. Two recent studies of coal resources and reserves in the Southern Ute and Ute Mountain Reservations have been made (Shomaker and Holt, 1973; and Speltz, in press). This discussion is based largely on those studies. Earlier studies were made by the U.S. Geological Survey (Wood, Kelley, and MacAlpin, 1948; Barnes, 1953; and Barnes, Baltz, and Hayes, 1954).

Records of the Colorado Division of Mines, Denver, Colorado, indicate that approximately 31,500 tons (28,500 t) of coal have been produced from within the Indian reservation (Table 6). The old Ft. Lewis mine, sec. 1, T. 32 N., R. 12 W., produced coal as early as 1888 for use at Ft. Lewis; it produced intermittently until 1941 for a total output of about 13,500 tons (12,250 t). In the eastern part of the reservation, coal production was reported as early as 1913 and as recently as 1956.

TABLE 6
Recorded Coal Production Within the Southern Ute Indian Reservation
(Colorado Division of Mines, Denver, CO)

Name of Mine	Location			Dates of Production		Cumulative Prod., S.T.
	Section	T.	R.	First	Last	
Archuleta Co.						
Belino	NW¼NE¼ 32	33 N.	2 W.	1927	1956	2,833
Garcia	NW¼SE¼ 13	33 N.	3 W.	1948	1956	1,478
Garcia Strip	13	33 N.	3 W.	1953	1953	100
Martinez	32	33 N.	2 W.	1949	1953	148
O. K.	29	33 N.	2 W.	1934	1935	500
Talian	16	33 N.	3 W.	1913	1915	7,637
La Plata Co.						
Ft. Lewis (old)	1	32 N.	12 W.	1888	1941	13,557
Soda Springs	SE¼ 36	33 N.	12 W.	1928	1947	5,218
Total						31,471

Dakota Formation

The Dakota coal does not represent a favorable resource under present conditions because most of it is at depths greater than 3,000 feet (900 m) and thickness and distribution are erratic. Coal bed

thicknesses range from about 5 to 10 feet (2-4 m). In the deepest part of the basin under the reservation, depth to the Dakota is nearly 9,000 feet (2,700 m). Shomaker and Holt (1973, p. 4) estimate 4,407 million tons (4,000 million t) of coal in the Dakota in the Southern Ute Reservation.

Nearest analysis of Dakota coal given by Shomaker and Holt (1973, table 1, appendix) is from a core hole in NE $\frac{1}{4}$ NE $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 18, T. 36 N., R. 14 W., about 9 miles (14 km) northwest of the reservation. On an "as received" basis, the sample showed 3.5 percent moisture, 19.1 percent volatile matter, 31.0 fixed carbon, and 46.4 percent ash; heating value was 6,810 Btu per pound (3,780 kg-cal/kg). On a moisture-free basis, the analysis gave 19.8 percent volatile matter, 32.1 percent fixed carbon, and 48.1 percent ash; heating value was 7,060 Btu per pound (3,920 kg-cal/kg).

Menefee Formation

The Menefee Formation of the Mesaverde Group, or its equivalent, is present under the entire reservation. Shomaker and Holt (1973, p. 5) believe that coal of minable thickness in the Menefee is present from about R. 7 W. to the western edge of the reservation but is not present in the eastern part. With 4 to 16 coalbeds, aggregate thickness reaches 42 feet (12.8 m) with an average bed thickness of 3.9 feet (1.2 m). Shomaker and Holt estimate that about 12 billion tons (10.9 billion t) of coal are present under the reservation in the following categories:

<u>Depth</u>	Menefee coal resources		<u>Remarks</u>
	Total million S.T.	Under Indian lands, million S.T.	
Less than 500'	183	161	In T. 34 N., Rs. 12-13 W.
500' to 1,000'	3,496	2,274	
Greater than 1,000'	<u>8,385</u>	<u>7,490</u>	
	12,064	9,925	

Speltz (in press, p. 29) describes the Menefee coal as high-volatile A, B, or C bituminous in rank and locally as of coking quality. His analyses of 270 samples of Menefee coal from La Plata County show the following on an "as received" basis:

	<u>High</u>	<u>Low</u>	<u>Mean</u>
Moisture, percent	10.7	1.5	3.9
Volatile matter, percent	42.7	28.4	39.7
Fixed carbon, percent	58.0	43.1	52.7
Ash, percent	28.5	2.5	7.5
Sulfur, percent	5.1	.4	1.5
Heating value, Btu/lb	14,410	10,380	13,120
Heating value, Kg-cal/kg	8,006	5,767	7,289

Fruitland Formation

The Fruitland Formation crops out around the margins of the San Juan basin and is present at the surface in both the western and eastern parts of the reservation. It is the only formation from which coal has been produced within the reservation. Shomaker and Holt (1973, p. 7, 10, and figs. 16 and 17) examined the well logs furnished by Peabody Coal Co. from its 19,452-acre (7,870 ha) coal lease in the western part of the Southern Ute reservation. They estimated about 400 million tons (363 million t) of coal under overburden of 250 feet (76 m) or less. Dip of the beds is from 6 to 18 degrees. Coal thicknesses aggregate 110 feet (34 m) mostly in three zones with net coal thicknesses of 13.4, 16.6, and 20.9 feet (4.1, 5.1, and 6.4 m).

Shomaker and Holt (1973, p. 10, table 7) make no effort to estimate shallow coal reserves east of the Peabody lease blocks, but they give a figure of 1,880 million tons (1,705 million t) of coal at depths less than 500 feet (152 m) including the 400 million tons (363 million t) under the Peabody lease and an unknown quantity at less than 250 feet (76 m) in the eastern part of the reservation. There is an estimated 2,261 million tons (2,050 million t) under Indian Lands at depths between 1,000 and 2,000 feet (305 and 610 m); 17,066 million tons (15,482 million t) between 2,000 and 3,000 feet (610 and 915 m); and 3,858 million tons (3,500 million t) at depths greater than 3,000 feet (915 m).

Speltz (in press, p. 33) gives a typical analysis of Fruitland coal, which he describes as high-volatile A or B bituminous in rank and generally noncoking: Moisture, 5.4 percent; volatile matter, 36.8 percent; fixed carbon 49.0 percent; ash, 8.8

percent; and sulfur, 0.9 percent. Heating value was 12,660 Btu/lb (7,033 kg-cal/kg).

In a later report on strippable coal reserves on the Southern Ute Indian Reservation, Speltz (written commun., July 3, 1975) estimated that 116 million tons (105 million t) of clean coal are recoverable by surface mining. He believed this was sufficient to support a 1,000-megawatt steam/electric powerplant, a 10,000-barrel-per-day coal liquefaction plant, or a 3-million-ton-per-year (2.7 million t) coal slurry pipeline.

Uranium

The geologic environment of the Southern Ute Reservation offers some potential for the occurrence of uranium deposits in the Morrison and Cutler Formations. The Morrison Formation contains major uranium deposits in similar environments elsewhere in Colorado and New Mexico, and the Cutler Formation is believed to offer a potential for uranium. An exploration program to test these formations should begin by evaluating any available gamma-ray logs of the hundreds of oil and gas wells on the Reservation, for high gamma-ray readings in the Morrison and Cutler Formations. Coincidentally, this step is currently (Spring 1976) being done as part of a resource evaluation program by the Branch of Uranium and Thorium Resources of the U.S. Geological Survey.

Sand and Gravel

Sand and gravel resources are plentiful on the reservation, both as terrace gravels and as alluvium. Because of the sporadic use of sand and

gravel pits, no attempt has been made to distinguish on [Figure 2](#) between pits currently being used and those temporarily or permanently abandoned.

Records of sand and gravel production are poorly maintained and use of the commodity is on an informal basis. The tribe uses the material for its own maintenance work and an occasional contract is made with the county or State highway departments for their road work.

MINERAL LEASING

Leasing of minerals on the Southern Ute Indian Reservation is basically controlled by the Omnibus Mineral Leasing Act of 1938, with implementing regulations in 25 CFR part 171. However, because the Southern Ute Tribe is organized under the provisions of the Indian Reorganization Act of June 18, 1934 (48 Stat 984; U.S.C. 461-479), the tribal council's ordinance, resolution, or other action authorized under their constitution, by law, or charter may supersede the regulations in 25 CFR part 171.

Regulations governing mineral leasing on Indian lands allow considerable flexibility in determining specific terms and procedures. This flexibility permits the tribal governments to make changes that best serve the tribes' needs (U.S. Federal Trade Commission, Bur. of Competition). The following general provisions, from "American Law of Mining," published by the Rocky Mountain Mineral Law Foundation (1966), provide a base on which specific lease terms may be established.

Leases may be made by the Southern Ute Tribal Council, with approval by the Secretary of

the Interior or his authorized representative. Lease terms may not exceed 10 years or as long thereafter as minerals are produced in paying quantities. Oil and gas leases must be offered for sale at a public auction or upon sealed bids but leases for other minerals may be negotiated and approved without public notice and sale.

The acreage of a single lease may not exceed 2,560 acres (1,037 ha) except for coal leases in which case larger areas may be approved by the Commissioners of Indian Affairs if in the interest of the tribe and necessary for a particular purpose. Annual lease rentals are fixed at \$1.25 per acre for oil and gas leases and not less than \$1.00 per acre plus annual development expenditures of not less than \$10.00 per acre for other minerals.

Royalties on mineral production vary according to the mineral involved. For most minerals, the minimum royalty is 10 percent of the value of the mineral at the nearest shipping point. Royalties for oil and gas and natural gas liquids may not be less than 16.67 percent (U.S. Federal Trade Commission, p. 70). Coal royalty is not less than 10 cents per ton of mine-run coal.

Prospecting permits may be issued by the Superintendent of the Agency with the consent of the tribal council.

Leasing of allotted lands is governed by the Indian Appropriation Act of 1909, 35 Stat. 783 (1909), 69 Stat. 540 (1955), 25 U.S.C. Sect. 396 (1958), and the regulations are spelled out in 25 CFR Sect. 172.1 to 172.33.

MINERAL MARKETS AND TRANSPORTATION

The local market for mineral commodities is limited to sand and gravel and small amounts of coal. For most of the mineral resources on the reservation, the national market would be the ultimate potential outlet. Petroleum and natural gas and coal require complex processing plants; these, in turn, require sufficient supplies of raw materials to assure a constant, longtime flow through the processing system.

The reservation is handicapped because rail transportation for high-bulk, low-value crude material is not readily available. Nearest rail outlet is the Denver & Rio Grande Western Railroad (D&RGW) at Ridgway, Colo., 107 miles (172 km) north of Ignacio over 11,018-foot (3,358 m) Red Mountain Pass; from Ridgway, it is an additional 47 miles (76 km) north to the D&RGW mainline at Delta, Colo. Another D&RGW railhead is available at Alamosa, 143 miles (230 km) east of Ignacio over 10,850-foot (3,307 m) Wolf Creek Pass. To the south, the mainline of the Atchison, Topeka & Santa Fe Railroad (AT&SF) is at Gallup, N. Mex., 187 miles (301 km) from Ignacio.

Petroleum and natural gas reach national markets through pipeline systems. Northwest Pipeline Corporation's Ignacio natural gas processing plant is in sec. 36, T. 34 N., R. 9 W., and provides an outlet for both natural gas and natural gas liquids. With a rated capacity of 300 million ft³ (8.5 million m³) of gas per day (largest in Colorado), it receives raw gas from wells in the northern San Juan Basin, extracts propane, butane, and natural gasoline, and puts the dry gas into Northwest's 26-inch (66-cm) pipeline to Sumas, Wash. The natural gas liquids are sold at the plant and transported in tank trucks. Principal gas pipelines are shown on [Figure 4](#) Petroleum from the Red Mesa field is trucked to refineries.

MAP COVERAGE

Except for the portion east of longitude 107°15'W., the reservation has been mapped on standard 7½-minute quadrangles (scale 1:24,000). The east end is covered by the 19-year-old Pagosa Junction 15-minute quadrangle (scale 1:62,500). The following is a list of the quadrangles, with publication dates. All maps are available from the U.S. Geological Survey, Branch of Distribution, Building 41, Denver Federal Center, Denver, Colo. 80225.

Allison, 1954 (Photorevised 1971)
Basin Mtn., 1968
Bayfield, 1968
Bondad Hill, 1968
Carracas, 1954 (Photorevised 1971)
Chimney Rock, 1968
Gem Village, 1968
Ignacio, 1968
Kline, 1968
Loma Linda, 1968

Long Mtn., 1968
Mormon Reservoir, 1968
Pagosa Junction, 1957 (15-min.)
Pargin Mtn., 1968
Pinkerton Mesa, 1968
Red Horse Gulch, 1968
Red Mesa, 1968
Tiffany, 1968
Trail Canyon, 1966

Aerial photography covering the entire reservation, flown in August 1973, is available from the U.S., Forest Service, Building 46, Denver Federal Center, Denver, Colo.

would require a less deep hole than those suggested above--probably about 7,000 feet would suffice.

Coal

It is doubtful that limited drilling could contribute significantly to the data assembled by Shomaker and Holt (1973). Successful development of Peabody Coal Company units existing lease in the western part of the reservation might encourage exploration activity.

RECOMMENDATIONS

Oil and Gas

The western and central part of the reservation has been tested for oil and gas by numerous shallow holes and a few deep ones, and probably can be considered to be adequately explored for significant fields. The eastern part of the reservation, however, is less well known as to subsurface structure or oil and gas potential, especially in the area between Piedra Peak and Car Creek, and a modest two-stage program of exploration might prove worthwhile. The first stage should be compilation of all available mapping and drilling data on the area of Ts. 32 and 33 N., and Rs. 2-6 W., as a basis for identifying potentially favorable structures. The second stage should then be drilling of one or possibly two holes per township to the depth of the Paradox Member of the Hermosa Formation in order to test any favorable structures identified in the first stage; these holes might have to be on the order of 15,000 feet deep to penetrate from the top of the Nacimiento through the Hermosa. Also as a part of the second stage, the potential for oil and gas accumulation on the Stinking Springs anticline might be tested; this structure crosses the "outlier" at the northeast corner of the reservation, where the Dakota Sandstone is at the surface, so a test of the Paradox

REFERENCES

- Barnes, Harley, 1953, Geology of the Ignacio area, Ignacio and Pagosa Springs quadrangles, La Plata and Archuleta Counties, Colo., U.S. Geol. Survey Oil and Gas Invest. Map OM-138.
- Barnes, Harley, Baltz, E. H., and Hayes, P. T., 1954, Geology and fuel resources of the Red Mesa area, La Plata and Montezuma Counties, Colo., U.S. Geol. Survey OM-149.
- Colorado Oil and Gas Conservation Commission, 1975, 1974 oil and gas statistics: Oil and Gas Conservation Commission, Dept. of Natural Resources, 145 p.
- Fassett, J. E., and Hinds, J. S., 1971, Geology and fuel resources of the Fruitland Formation and Kirtland Shale of the San Juan Basin, New Mexico and Colorado: U.S. Geol. Survey Prof. Paper 676, 76 p.
- Haynes, D. D., Vogel, J. D., and Wyant, D. G., 1972, Geology, structure, and uranium deposits of the Cortez quadrangle, Colorado and Utah: U.S. Geol. Survey Misc. Geol. Inv. Map I-629.
- Petroleum Information, 1951, Resume of Rocky Mountain Oil and Gas Operations for 1950: Published by Petroleum Information, Denver, Colo., 187 p.
- _____, 1952, Resume of Rocky Mountain Oil and Gas Operations for 1951: Published by Petroleum Information, Denver, Colo., 264 p.
- Reeside, J. B., Jr., 1924, Upper Cretaceous and Tertiary formations of the western part of the San Juan Basin, Colorado and New Mexico: U.S. Geol. Survey Prof. Paper 134, 117 p.
- Rocky Mountain Association of Geologists, 1954, Oil and Gas Fields of Colorado, 1954: Rocky Mountain Assoc. of Geologists, Denver, Colo., 302 p.
- _____, 1962, Oil and gas field volume, Colorado-Nebraska, 1961: Rocky Mountain Assoc. of Geologists, Denver, Colo., 348 p.
- Rocky Mountain Mineral Law Foundation, 1966, American Law of Mining: v. 1, Title II, Chap. VI, Matthew Bender & Co., New York, N. Y.
- Shomaker, J. W., and Holt, R. D., 1973, Coal resources of Southern Ute and Ute Mountain Ute Indian Reservations, Colorado and New Mexico: New Mexico Bur. Mines and Mineral Resources Circ. 134, 22 p.
- Speltz, C. N., Strippable coal resources of Colorado: U.S. Bur. Mines Inf. Circ. (in press).
- Steven, T. A., Lipman, P. W., Hail, W. J., Jr., Barker, Fred, and Luedke, R. G., 1974, Geologic map of the Durango quadrangle, southwestern Colorado: U.S. Geol. Survey Map Misc. Geol. Inv. Map I-764.
- U.S. Congress. Indian Appropriation Act of 1909, 35 Stat. 783. Indian Reorganization Act of 1934, 48 Stat. 984. Omnibus Mineral Leasing Act of 1938, 52 Stat. 347.
- U.S. Department of Commerce, 1974, Federal and State Indian Reservations and Indian trust areas: U.S. Dept. of Commerce, 604 p.
- U.S. Federal Trade Commission, 1975, Report to the Federal Trade Commission on mineral leasing on Indian lands: U.S. Federal Trade Commission, Bureau of Competition Staff Rept., 226 p.

Wood, G. H., Kelley, V. V., and MacAlpin, A. J.,
1948, Geology of the southern part of
Archuleta County, Colo., U.S. Geol. Survey
Oil and Gas Invest. Map OM-81.

TABLE 3. Nomenclature of outcropping rock units of the Southern Ute Indian Reservation.

ERA	SYSTEM	SERIES	GROUP AND FORMATION
	Tertiary and Quaternary	Pliocene to Holocene	Alluvium Unconformity
C E N O Z I C	Tertiary	Eocene or younger	Intrusive igneous rocks.
		Eocene	San Jose Formation
		Paleocene	Nacimiento Formation Ojo Alamo Formation
	Cretaceous and Tertiary	Upper Cretaceous and Paleocene	Animas Formation
	Cretaceous	Upper Cretaceous	Kirtland Shale
			Fruitland Formation
			Pictured Cliffs Sandstone
			Lewis Shale
			Mesaverde Group Formation Cliff House Sandstone Menefee Formation Point Lookout Sandstone
			Mancos Shale Dakota Sandstone Disconformity
		Lower Cretaceous	Burro Canyon Formation Disconformity
Meso- zoic	Jurassic	Upper Jurassic	Morrison Formation Wanakah Formation

TABLE 4.— Mineral production and royalties from tribal and allotted lands,
Southern Ute Indian Reservation, 1970-1974.

Source: U.S. Geological Survey, Conservation Division, Roswell, N. Mex.

Tribal									Allotted		
Year	Petroleum		Natural Gas		Total Tribal Royalty, dollars	Natural Gas		Grand Total Royalty, dollars			
	Production, barrels	Royalty, dollars	Production, million Ft ³	Royalty, dollars		Production million Ft ³	Royalty, dollars				
1970	1,700.37	550.50	15,934	298,632.36	299,182.86	504	10,683.81	309,866.67			
1971	2,485.79	893.52	14,516	269,206.13	270,099.65	632	12,865.44	282,965.09			
1972	1,865.72	672.47	13,443	316,749.53	317,422.00	541	13,725.68	331,147.68			
1973	1,093.80	692.62	15,285	429,713.71	430,406.33	643	20,969.46	451,375.79			
1974	<u>2,655.29</u>	<u>2,059.63</u>	<u>13,294</u>	<u>400,576.86</u>	<u>402,636.49</u>	<u>615</u>	<u>20,076.94</u>	<u>422,713.43</u>			
Total	9,800.97	4,868.74	72,472	1,714,878.59	1,719,747.33	2,935	78,321.33	1,798,068.66			

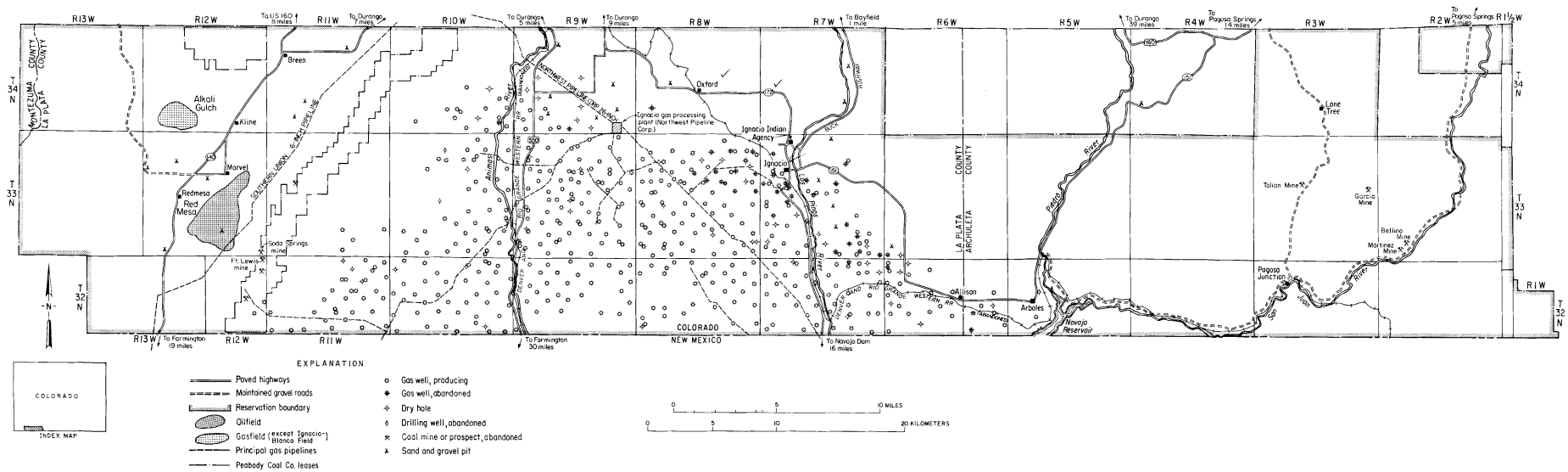


Figure 1. Map showing geography and land ownership, Southern Ute Indian Reservation.

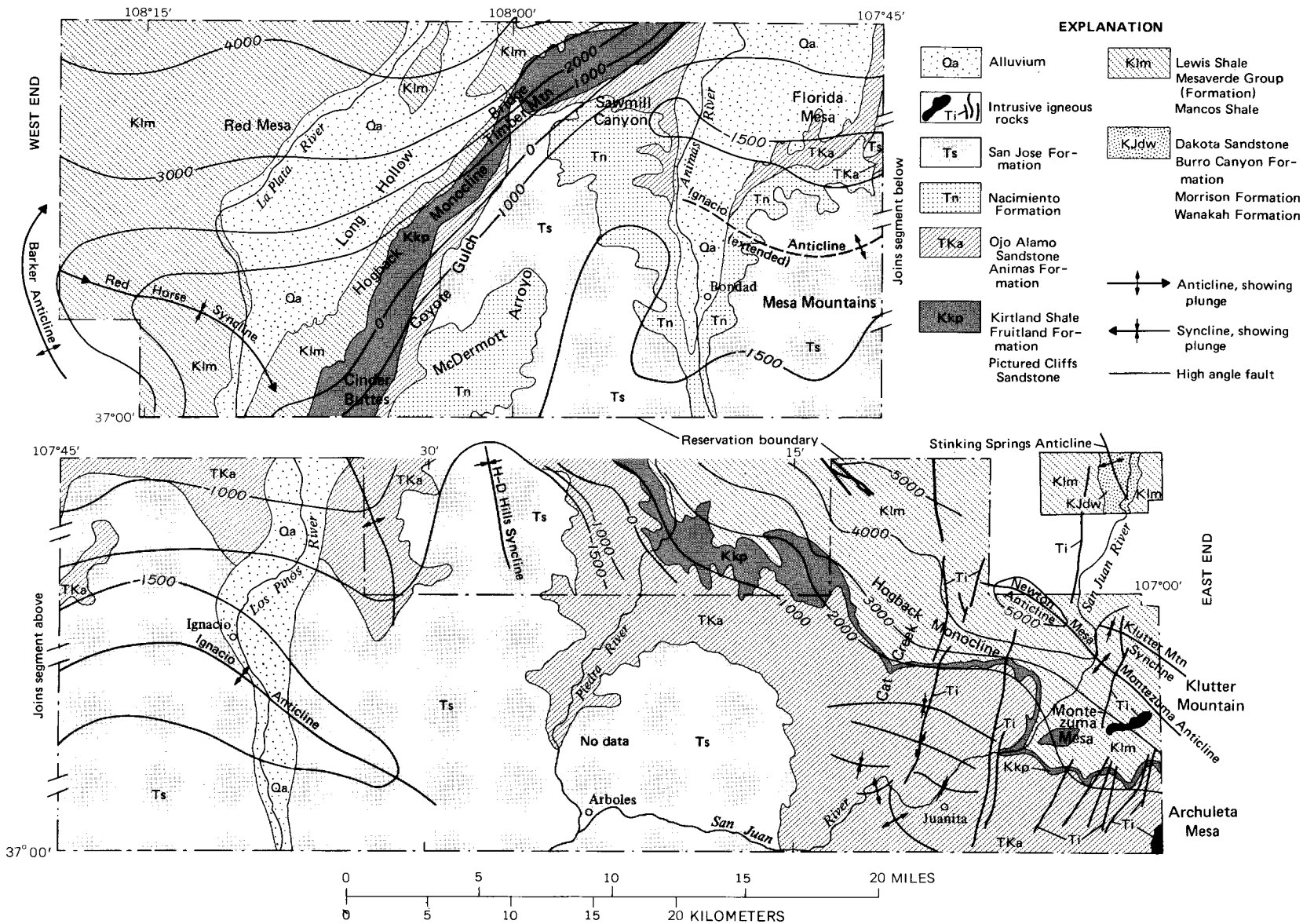


Figure 2. Generalized geologic and structure map of the Southern Ute Indian Reservation.

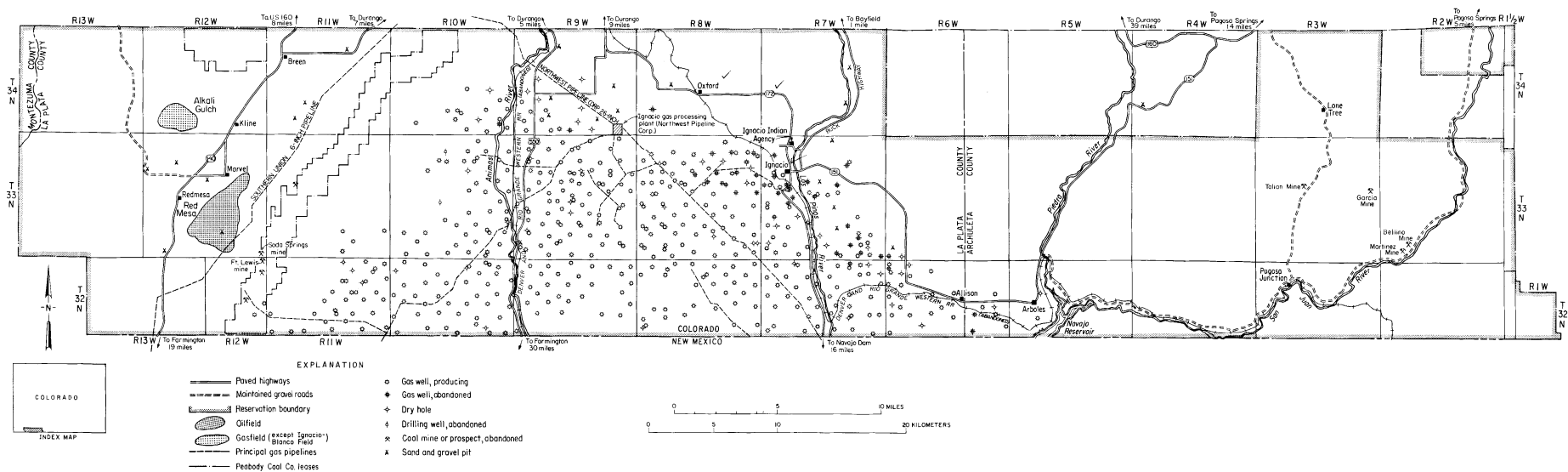


Figure 3. Mineral resource map of the Southern Ute Indian reservation.

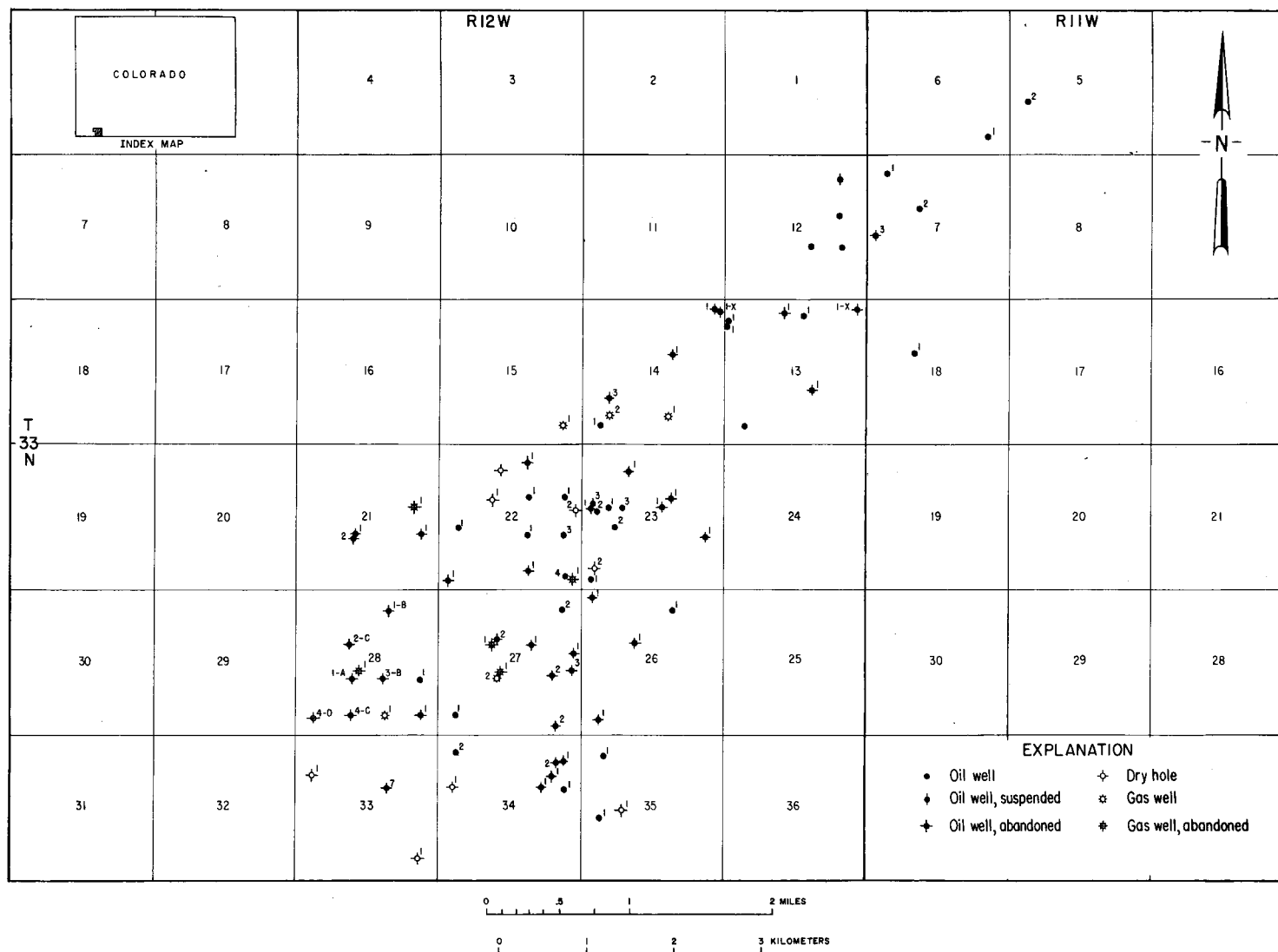


Figure 4. Map showing oil and gas wells in Red Mesa Oilfield. (Adapted from U.S. Geol. Survey Cons. Division Map No. Roswell 96).